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METHODS FOR CHANGING THE BANDWIDTH OF AN ISOCHRONOUS CHANNEL IN A CIRCUIT SWITCHED NETWORK

Technical Field of Invention

The present invention relates to methods for changing the bandwidth of an existing isochronous channel in a circuit switched time division multiplexed network of the kind wherein data are transferred on bitstreams, each bitstream being divided into recurrent frames and each frame being divided into time slots, said isochronous channel comprising a set of time slots within each frame of a bitstream between a first node and a second node.

Background of the Invention

In recent years, the need for network solutions providing quality of service in high bandwidth applications has evolved as a result of the increasing demand for transfer of, e.g., real-time speech, video and multimedia over networks such as the Internet.

The use of circuit switched networks, which have the inherent property of providing each host with a guaranteed bandwidth, has been found to provide may advantageous features in this context.

A new circuit switched network solution, which has received much interest over the last few years, is known as DTM (Dynamic synchronous Transfer Mode). In a DTM network, circuit switched isochronous channels may be dynamically established, modified, and terminated based upon changes in user transfer capacity requirements.

An advantage with DTM is that the bandwidth of an established isochronous channel may be dynamically changed by the allocation or deallocation of time slots to said channel. However, changing the bandwidth of an existing channel requires synchronization between sender and receiver(s), as well as intermediate nodes, to avoid losing data (in case the sender increases the number of

slots allocated to a channel before the receiver does), or to avoid receiving garbage data (if the receiver increases the number of slots allocated to said channel before the sender does).

Different suggestions have been made of how to arrange said synchronization. One suggested solution is to simply stop sending data while the bandwidth change is being performed. However, this means that the channel is unused during a period of time, thus inevitably leading to a waste of bandwidth resources. Another suggested solution is to ensure that the bandwidth change is being made simultaneously at sender, receiver, and any intermediate nodes, by numbering the cycles and, using control signaling, agreeing on which specific cycle to effectuate the change. This of course has the drawback of requiring extra signaling as well as provision of a cycle counting mechanism.

In view of the above, an object of the invention is to provide a simple, reliable, safe and effective mechanism for synchronizing bandwidth changes in a circuit switched networks of the kind mentioned in the introduction, especially within a DTM network.

Summary of the Invention

The above mentioned and other objects of the invention are achieved by the invention as claimed in the accompanying claims.

Hence, according to one aspect of the invention, there is provided a method of the kind mentioned in the introduction, said method being used when increasing the bandwidth of a channel and being characterized by the steps of: allocating to said channel, in addition to said set of time slots, one or more additional time slots within each frame of said bitstream; using, during a period of time, only a subset of the time slots of the enlarged set of time slots formed by said a set of time slots and said one or more additional time slots for

transmitting payload data pertaining to said channel, the number of time slots in said subset of time slots not exceeding the number of time slots in said a set of time slots, and providing, during said period of time, said bitstream with information indicating that the remaining time slots of said enlarged set of time slots are currently not used for transferring payload data; and using, after said period of time, said a set of time slots as well as said one or more additional time slots on said bitstream for transmitting payload data pertaining to said channel.

According to another aspect of the invention, there is provided a method of the kind mentioned in the introduction, said method being used when decreasing the bandwidth of a channel and being characterized by the steps of: said first node using, during a period of time, only a portion of said set of time slots for transmitting payload data pertaining to said channel and providing said bitstream with information indicating that the remaining time slots of said set of time slots are currently not used for transferring payload data; said first node providing said second node with information declaring that said remaining time slots are to be deallocated from said channel; and said first node, after said period of time, deallocating said remaining time slots of said first set of time slots from said channel while discontinuing providing said information indicating that said remaining time slots of said set of time slots are currently not used for transferring payload data and.

The invention is thus based upon the idea of not using, during the bandwidth change, those time slots that are to be allocated/deallocated to/from a channel (or at least a number of time slots (within the channel) corresponding to the number of time slots that are to be allocated/deallocated to/from the channel), and to provide the bitstream with information designating them as providing invalid data, i.e. as not payload data, typically

by marking said time slots as idle, while at the same time using those time slots that are to be unchanged (i.e. slot already belonging to the channel, in the case of a bandwidth increase, or slots that are not to be deallocated from the channel, in the case of a bandwidth decrease) for transferring payload data.

It is to be noted that, if so desired, the way in which the invention is realized will partly, but not necessarily, depend on whether or not channel or slot based mapping is used at a node handling the bitstream. For example, a node, such as a switch node, providing channel based mapping of said channel, i.e. generally not being concerned with which time slot data that goes into which time slot position on a bitstream within the channel as long as the sequential order of time slots within the channel is preserved, may during some conditions operate less stringent with respect to which time slots within the channel that are not to be used for transferring payload data during a bandwidth change according to the invention. However, a switch node providing slot based mapping of said channel, i.e. repeatedly mapping a specific time slot position on one bitstream into a specific corresponding time slot position on another bitstream, will generally have to operate more stringent with respect to which specific time slot positions within the channel that are not to be used for transferring payload data during a bandwidth change according to the invention.

According to a preferred embodiment, which of course is not limited to the context of slot based mapping although being especially useful in that context, said step of using a subset of time slots for transmitting payload data during said period of time comprises using, during said period of time, only said a set of time slots for transmitting payload data pertaining to said channel and providing, during said period of time, said bitstream with information indicating that said one or more addi-

tional time slots are currently not used for transferring payload data.

For example, if a sending node wants to allocate additional resources to a channel, it may at any time allocate, and start using, additional time slots on the bitstream that it is connected to, as long as it marks the additional time slots as being idle and only transmits payload data in the time slots that already belonged to the channel prior to said allocation. This will ensure that a downstream node, such as the receiving node or an intermediate switch node, will not immediately consider data received in said additional resources as valid data. When the sending node then receives information indicating that downstream nodes have allocated the desired extra bandwidth to the channel, the sending node may at any time discontinue transmitting said information designating said additional time slot as being idle and instead start transmitting payload data using said additional time slots as well.

Typically, said period of time will preferably end when, or shortly after, the reception at the sending node of said information indicating that downstream nodes have allocated the desired extra bandwidth to the channel and are ready to transfer data therein. However, according to an alternative embodiment, said period of time will be fixed period of time. In such a case, the sending node, after having sent a request for additional capacity to downstream nodes, and after having waited said fixed period of time, will assume that any intermediate nodes and the receiving node will have had enough time to allocate the necessary resources and to provide the necessary mapping. The sending node will thus simply assume that the extra resources are "up and running" and consequently start transmitting payload data in said additional time slots. This, of course, may result in loss of data, but will on the other hand provide a simpler mechanism requiring less signaling.

Similarly, having received instructions to allocate additional resources to an existing channel, an intermediate node handling said channel may at any time allocate additional time slots to said channel on an outgoing bitstream even if said intermediate node has not yet received instructions as to which time slots that will constitute said additional resources on an incoming bitstream, as long as the intermediate node provides the outgoing bitstream with information indicating those time slots of the outgoing bitstream that are so far not transferring payload data. However, when having received instructions as to which time slots that constitute said additional resources slots on said incoming bitstream, and that it is permitted to start mapping data therefrom, the intermediate node will provide the necessary mapping of data and will discontinue transmitting said information indicating that said additional time slots are so far not transferring payload data unless information received in the incoming bitstream suggests otherwise.

An advantage of the invention is thus that the need for stringent bandwidth change synchronization between nodes involved in the management of a channel is relaxed. Using the invention, the sending, receiving, and intermediate nodes may, separately and with comparatively relaxed synchronization requirements, allocate additional time slots, set-up mapping between incoming and outgoing additional time slots, and start using additional time slots, as long as said additional time slots are for the time being marked as being idle, i.e. not providing payload data. When control signaling between nodes then indicate that the channel from sender to receiver is "up and running", the sending node may at any time, without any need for notifying downstream nodes, simply switch from marking said additional time slots as idle to transmitting payload data into said additional time slots.

Similarly, when decreasing the size of a channel, the sending node will, for example, simply stop transmit-

ting payload data in one or more time slots to be deallocated from the channel, and instead start marking said one or more time slots as being idle, thereby making sure that downstream nodes will not consider data provided in said one or more time slots as valid payload data, while continuing transmitting payload data in those time slots that are not to be deallocated. The sending node may then, at any time, instruct downstream nodes, such as the receiving node or an intermediate node, to deallocate resources corresponding to said one or more time slots from said channel. When having received confirmation from said downstream nodes that they are aware that the subject resources are no longer to be part of the channel, the sending node may, at any time, completely deallocate said one or more time slots from the channel without any further need for synchronizing the deallocation with other nodes.

Consequently, the decisions at different nodes as to when to allocate and start using additional time slots, or when to stop using and deallocate time slots, may be made more independently than compared to prior art solutions.

Of course, an important advantage of the invention is that payload data are transmitted (at least if so desired) in the unaffected time slots of the channel while the bandwidth change is being executed, thereby efficiently limiting the degree of temporary bandwidth blocking during the change.

According to a preferred embodiment of the invention, said information indicating that a time slot is not used for transferring payload data is provided by the step of marking said time slot as being idle, typically by writing an idle time slot pattern, for example, a code word, into said time slot or by setting a one-bit flag of the time slot to indicate that the time slot is invalid. In such cases, the information stating that a time slot

does not transfer payload data is provided within the time slot itself.

However, the manner in which one or more time slots are marked as not providing payload data may be selected in many other ways. For example, the information indicating that a time slot is not providing payload data need not be provided within the time slot as such, but may be derived from another location or part of the associated bitstream, i.e. using some kind of out of band signaling.

In this context, it is to be noted that the actual writing of a code word, setting of a flag, or out of band signaling may just as well be provided by a head end node marking by default essentially all slots on the bitstream as idle, thus leaving it up to downstream nodes, such as the transmitting node, to "unmark" those slots that will transfer payload data.

Of course, even though the degree of dynamics by which the features of the invention may be utilized at the nodes handling a channel will depend upon in which degree the nodes handling the channel are equipped with capability to detect, interpret, and generate said information indicating that a time slot is not providing payload data. However, even if only the receiving node is capable of detecting and discarding idle time slots and only the sending node have access to a way of making sure that time slots not providing payload data are designated as being non-valid, the invention will still come to advantageous use.

Furthermore, if said information designating that a time slot is not providing payload data is provided by the writing of an idle block into said time slot, this information is easily propagated to a next hop bitstream by the simple mapping of the idle block from said time slot to a time slot of the channel on the next hop bitstream. Consequently, no extra processing in addition to mere time slot mapping is in such a case needed at the intermediate node to detect the presence of an idle time

slot and to provide the next hop bitstream with corresponding information.

A problem which may arise when allocating additional time slots to a channel (or deallocating time slots from said channel) and when said channel extends over more than one bitstream, is that whereas one node may want to allocate, for example, an additional time slot occupying a time slot position after the last one of the time slots already allocated to the channel on the respective bitstream, another node may want to allocate a time slot occupying a time slot position before the first one of the time slots already allocated to the channel, or perhaps occupying a time slot position in the middle of the time slots already allocated to the channel, on the respective bitstream. Consequently, if mapping were to be provided between these additional time slots only, not considering the different positions or ordering (within the channel) of the additional time slot, the sequential order of data transmitted within the channel may be altered, which in some application will cause errors in the data interpretation at the receiver. (Generally, this problematic situation will not occur at a node that uses channel based mapping, since such a node will typically make sure that the sequential order data received within a channel is preserved).

One way to avoid this problem would be to only allow intermediate nodes to allocate new slots to a channel in the same time slot order as the sending node. However, this would drastically decrease the possibility to set up the channel and thus result in unnecessary blocking.

Another way of solving this problem is to make a re-mapping at each concerned intermediate node so as to ensure that the order of time slot data is preserved even if the position of the "new" time slot with respect to the other time slots allocated to the channel is different on different bitstreams. Of course, such a re-mapping need then to take place before the sending node

starts to send payload data instead of idle data blocks in said additional time slots. Consequently, as used herein, the term "re-mapping" refers to the situation wherein an existing mapping instruction designating the mapping of data from a time slot position on a first bitstream to a time slot position on a second bitstream is altered to designate the mapping of data from said time slot position on said first bitstream to another time slot position on said second bitstream.

According to a preferred embodiment of the invention, in order to make sure that said re-mapping doesn't result in that payload data is re-mapped to a slot not yet recognized by a downstream receiving node as belonging to the channel, any re-mapping to be performed among the time slots forming the channel at an intermediate node, as a result of the change of the amount of resources allocated to said channel, is carried out after the completion of any re-mapping performed among the time slots forming the channel at a downstream intermediate node located closer to a receiver of the channel than said first mentioned intermediate node. In other words, the re-mapping is performed backwards, starting from the intermediate node located closest to the receiving node. When having done it's re-mapping, and having made sure that the receiving node is aware that the additional slots now belongs to the channel, the last intermediate node will then preferably notify the upstream next hop intermediate node that the re-mapping is completed up to that location, said upstream next hop intermediate node thereby being allowed to perform its own re-mapping, if so desired, and so on. When, finally, the intermediate node located closest to the sending node notifies the sending node that mapping, and re-mapping, has been established up to that location, the sending node may, at any time, start using the additional time slots for transmitting payload data.

Furthermore, when changing the mapping at an intermediate node, irrespective of it involving re-mapping of an already existing mapping pattern or involving a simple incorporation of an additional time slot mapping instruction, the switching from the old mapping pattern to the new mapping pattern is preferably performed at frame start, for example by switching, at frame start, from using an first mapping table containing old mapping instructions for each slot of an input frame to using a second mapping table containing new mapping instructions for each slot of said input frame.

Even though applicable in many different types of circuit switched time division multiplexed networks using isochronous channels, the most preferred use of the invention is in a so called Dynamic synchronous Transfer Mode (DTM) network.

Also, a "first" and "second" (as well as "third") node according to the claims need not necessarily be the nodes at which the subject channel originates and terminates, respectively, but may simply define a network path forming a portion of the total length of the channel.

As used herein, the term "isochronous channel" refers to a channel carried on a bitstream wherein the frames of the bitstream occur at a regular pace and wherein the set time slots defining the channel on that bitstream occupies the same time slot positions within each frame on that bitstream.

Furthermore, a thorough description of how to incorporate and detect as such the presence of information designating time slots as not providing payload data is found in the co-pending patent application SE 9703449-0, the description thereof hereby being incorporated by reference.

The above-mentioned and other aspects, features, and advantages of the invention will be evident from the accompanying claims and from following description of exemplifying embodiments thereof.

Brief Description of the Drawings

Exemplifying embodiments of the invention will now be described with reference to the accompanying drawings, wherein:

Fig. 1 schematically shows a DTM network;

Figs. 2a-2c schematically show allocation of time slots to channels on a bitstream; and

Figs. 3a-3f schematically show a simplified view of a DTM network and corresponding bitstreams during changes of channel bandwidth; and

Figs. 4a-4c schematically show a simplified view of three DTM bitstreams during a change of channel bandwidth requiring re-mapping of time slots.

Detailed Description of Preferred Embodiments

A circuit switched time division multiplexed network, operating according to a DTM (Dynamic synchronous Transfer Mode) protocol will now be described with reference to Fig. 1. In Fig. 1, a set of nodes N1, N2, N3, N4, N5, and N6 are connected via two bi-directional links, one formed by bitstreams B1 and B2 and the other formed by bitstreams B3 and B4. Nodes N1, N2, N3, and N4 are connected to bitstreams B1 and B2 and nodes N4, N5, and N6 are connected to bitstreams B3 and B4. Node N4 provides switching between the two links.

If, for example, node N2 is to send data to node N1, node N2 will establish a channel on bitstream B2 between node N2 and node N1. However, if node N2 is to send data to node N3, node N2 will establish a channel on bitstream B1 between node N2 and node N3. Furthermore, if node N2 is to send data to node N5, node N2 will establish a channel to node N5 using bitstream B1 between nodes N2 and N4 and bitstream B3 between nodes N4 and N5, as will be discussed in greater detail below.

The nodes are typically connected to end users E and are arranged to provide the end users with access to the

network. The end users are typically connected to the nodes via point-to-point connections, as shown at node N1, or, for example, using a ring topology, as shown at node N2. The network also comprises nodes not providing end user with network access but merely providing switching of data between different bitstreams of the network, such as the switch node N4. Furthermore, the DTM network NW is connected via node N6 to an external network ENW separate from the DTM network NW shown in Fig. 1.

The data transport structure of bitstreams B1-B4 within the DTM network in Fig. 1, using bitstream B1 as an example, will now be described with reference to Figs. 2a-2c.

As shown in Figs. 2a-2c, the bitstream B1 is divided into recurrent, essentially fixed sized frames. In turn, each frame is divided into a number of fixed sized time slots. As an example, if using a frame length of 125 μs, a time slot size of 64 bits, and a bit rate of 2 Gbps, the total number of time slots within each frame will be approximately 3900. As shown in Fig. 2a, the start of each frame is defined by a frame synchronization time slot F. Also, as shown in Fig. 2b, note that each frame ends with one or more guard band time slots G.

With reference to Figs. 2b and 2c, the time slots of a frame are generally divided into control slots C1, C2, C3, and C4, and data slots D1, D2, D3, and D4. The control slots are used for signaling between the nodes of the network, whereas the data slots are used for the transfer of payload data. At network start-up, each node connected to the bitstream B1 in Figs. 2a-2e is typically allocated at least one control slot within each frame. Furthermore, the data slots are generally divided equally among the nodes connected to the bitstream at network start-up. Consequently, as illustrated in Fig. 2b, node N1 will initially have access to a control slot C1 and a set of data slots D1 within each frame of the bitstream, node N2 will have access to a control slot C2 and a set

of data slots D2 within each frame of the bitstream, and so on. The set of slots allocated to a node as control slot(s) and/or data slot(s) occupy the same slot position within each frame of the bitstream. Hence, in the example, the control slot C1 belonging to node N1 will occupy the second time slot within each frame of the bitstream.

During network operation, each node may increase or decrease its access to control slots, thereby re-distributing the access to data slots or control slots among the nodes. For example, a node having a low transfer capacity demand may give away its access to time slots to a node having a higher transfer capacity demand. As will be described below, slots allocated to a node need not be consecutive slots, but may reside anywhere within the frame.

Allocation of time slots to channels will now be described with reference to Fig. 2c, illustrating the situation wherein node N2 of Fig. 1, having access to its control slot C2 and its range of data slots D2, has established four channels CH1, CH2, CH3, and CH4 on behalf of its end users. In this example, it is assumed that channel CH1 is from node N2 to node N3, whereas channels CH2, CH3, and CH4 are from node N2 to node N6 via node N4, node N4 merely acting as a switch node between bitstream B1 and bitstream B3. As shown, each channel is allocated a respective set of slots. In the example, the transfer capacity of channel CH1 is larger than the transfer capacity of channel 2, since the number of time slots allocated to channel CH1 is larger than the number of time slots allocated to channel CH2. The time slots allocated to a channel occupy the same time slot positions within each recurrent frame of the bitstream. Also, as is understood, time slots for channels CH2, CH3, and CH4 are correspondingly allocated on bitstream B3, as will be discussed further below.

Exemplifying procedures for changing the bandwidth of a channel will now be described with reference to Figs. 3a-3f.

Figs. 3a-3f schematically show a simplified view of a DTM network and corresponding bitstreams. The network 100 comprises four nodes 111, 112, 113, and 114 inter-connected via links (or bitstreams) 101, 102, and 103. Node 111 is connected to link 101, node 112 is connected to links 101 and 102, node 113 is connected to links 102 and 103, and node 114 is connected to link 103.

In Fig. 3a, it is assumed that an isochronous channel has been established from node 111 to node 114 via nodes 112 and 113. As schematically illustrated in Fig. 3a, the channel is defined to comprise two time slots (marked black in Fig. 3a) within each frame of bitstreams 101, 102, and 103. More specifically, the channel is defined to comprise the first and second time slot within each frame of bitstream 101, the first and third time slot within each frame on bitstream 102, and the third and fourth time slot within each frame on bitstream 103. Consequently, node 112 is arranged to map the content of the first and second time slot on bitstream 101 into the first and third time slot, respectively, on bitstream 102. Likewise, node 113 is arranged to map the content of the first and third time slot on bitstream 102 into the third and fourth time slot, respectively, on bitstream 103.

In this embodiment, node 111 manages allocation of time slots to said channel on bitstream 101, node 112 manages allocation of time slots to said channel on bitstream 102, and node 113 manages allocation of time slots to said channel on bitstream 103.

It is now assumed that, based upon an end user request or for some other reason, node 111 decides to increase the bandwidth of the channel, in this example by one time slot per frame. Using control signaling, node 111 then sends a bandwidth request to nodes 112 and 113

requesting an increase in the bandwidth allocated to said channel corresponding to one slot per frame.

Preferably using its own pool of free slots, node 111 then allocates the desired bandwidth, in this case one slot per frame, to the channel on bitstream 101, in this example the third time slot within each frame. It then transmits an announcement message to node 112 informing that time slot three on bitstream 101 is now to be part of the channel. However, node 111 does not immediately start sending payload data in said third time slot. Instead, at this point, node 111 only transmits payload data in the previously already allocated first and second time slots, but transmits idle data blocks into the third time slot within each frame of bitstream 101. Fig. 3b illustrates this situation. In Fig. 3b, node 111 has allocated an additional third time slot to said channel on bitstream, and is transmitting payload data into slots one and two and idle data blocks into slot three (as illustrated with an x-marking), whereas node 112 and 113 have not yet allocated any additional time slots to said channel on bitstreams 102 and 103.

Since node 112 in the situation shown in Fig. 3b has not yet allocated any additional time slots to the channel on bitstream 102, it has not yet started to map the third time slot from bitstream 101 into bitstream 102.

At this time, preferably using their own pools of free slots, nodes 112 and 113 will also allocate the desired bandwidth, in this example one slot per frame, to the channel on bitstreams 102 and 103, respectively. It is thus assumed that node 112 allocates the fourth time slot within each frame of bitstream 102 to said channel, and that node 113 allocates the sixth time slot within each frame of bitstream 103 to said channel. Also, node 112 will transmit an announcement message to node 113 informing that time slot four on bitstream 102 is now to be part of the channel, and node 113 will transmit an

announcement message to node 114 informing that time slot six on bitstream 103 is now to be part of the channel.

Thus, node 112 will start mapping data received in the third time slot on bitstream 101 to the fourth time slot on bitstream 102, and node 113 will start mapping data received in the fourth time slot on bitstream 102 to the sixth time slot on bitstream 103.

However, since node 111 still doesn't use the newly allocated time slot for transfer of payload data, but instead only transmits payload data in the previously already allocated two time slots, the idle data blocks transmitted by node 111 into time slot three on bitstream 101 will be mapped into the fourth time slot on bitstream 102 and then into the sixth time slot on bitstream 103, as illustrated in Fig. 3c. Hence, so far, the idle data blocks arriving at node 114 in time slot six of bitstream 103 will be discarded.

Having allocated the requested additional bandwidth and having established the necessary mapping (and having made sure that the receiving node 114 has been set-up to read data from time slot number six on bitstream 103 as part of the channel, node 113 will inform node 112, and node 112 will inform node 111, using control signaling, that the requested additional capacity is set-up.

Receiving this information, node 111 will determine that it may now go ahead and, at any time, start using the additional time slot for transferring payload data, which will then be mapped accordingly by nodes 112 and 113 to reach node 114, as is illustrated in Fig 3d.

As is understood, if an intermediate node, e.g. node 112 or 113, allocates the requested additional time slot to the channel before the upstream next hop node has allocated a time slot to said channel for said intermediate node to map data from, said intermediate node may still inform a downstream next hop node that said additional time slot is allocated to said channel as long as said intermediate node provides the additional time slot

with idle data blocks designating the additional time slot as not providing payload data.

Starting again from Fig. 3a, wherein an isochronous channel has been established from node 111 to node 114 via nodes 112 and 113, said channel being defined to comprise two time slots within each frame of the bitstreams 101, 102, and 103, it is now assumed that node 111, based upon an end user request or for some other reason, has decided to decrease the bandwidth of the channel, in this example by one time slot per frame.

Having decided which time slots to deallocate from said channel, node 111 will start transmitting idle data blocks into the time slot selected to be deallocated, but will continue to transmit payload data into the time slot not selected to be deallocated. In Fig. 3e, node 111 has decided to deallocate the second time slot within each frame on bitstream 101 from said channel and is thus transmitting payload data into slot one and idle data blocks into slot two (as illustrated with an x-marking).

Consequently, at this point, node 112 will map payload data received from time slot one within each frame of bitstream 101 into time slot one within each frame of bitstream 102, and idle data blocks received from time slot two within each frame of bitstream 101 into time slot three within each frame of bitstream 102. Likewise, node 113 will then map the payload data received from time slot one within each frame of bitstream 102 into time slot three within each frame of bitstream 103, and the idle data blocks received from time slot three within each frame of bitstream 102 into time slot four within each frame of bitstream 103, as illustrated in Fig. 3e.

Hence, at this point, the idle data blocks arriving at node 114 in time slot four of bitstream 103 are consequently discarded.

Using control signaling, node 111 now instructs nodes 112 and 113 to deallocate the time slot

corresponding to time slot two on bitstream 101 from said channel on their respective bitstreams, and instructs node 114 that time slot four on bitstream 103 is no longer to be considered part of the channel.

Having deallocated said time slots, nodes 112 and 113, as well as node 114 having received the correspon-ding instruction, send a confirmation message, using control signaling, to node 111 confirming that they have performed the requested deallocation. Receiving these confirmations, node 111 will deallocate said second time slot on bitstream 101 from said channel, thus leaving only one time slot allocated to said channel, as illustrated in Fig. 3f.

An exemplifying procedure for changing the mapping of time slots when performing a change of bandwidth will now be described with reference to Figs. 4a-3c.

Figs. 4a-4c schematically show a simplified view of a DTM network and corresponding bitstreams, comprising a first bitstream 201, a second bitstream 202, and a third bitstream 203.

In Fig. 4a, in similar to Fig 3a above, it is assumed that an isochronous channel has been established from a sending node on bitstream 201 to a receiving node on bitstream 203 via two intermediate nodes, wherein the first intermediate node provides time slot mapping between bitstream 201 and bitstream 202 and wherein the second intermediate node provides mapping beteen bit-stream 202 and 203. For simplicity, none of these nodes are showed in Figs 4a-4c.

As schematically illustrated in Fig. 4a, the channel is defined to comprise the first and second time slot within each frame of bitstream 201, the fourth and sixth time slot within each frame on bitstream 202, and the eighth and ninth time slot within each frame on bitstream 203 (as indicated by full line squares in Fig 4a). Conse-quently, the first intermediate node is arranged to map the content of the first and second time slot on bit-

stream 201 into the fourth and sixth time slot, respectively, on bitstream 202. Likewise, the second intermediate node is arranged to map the content of the fourth and sixth time slot on bitstream 202 into the eighth and ninth time slot, respectively, on bitstream 203.

It is now assumed that the sending node decides to increase the bandwidth of the channel, in this example by one time slot per frame. Using control signaling the sending node sends a request to the intermediate nodes requesting an increase in the bandwidth allocated to said channel corresponding to one slot per frame.

In this example, it is assumed that the sending nodes decides to allocate the third time slot within each frame on bitstream 201 to the channel and start sending idle data blocks therein (as indicated by the broken line square). However, it is also assumed that the second intermediate nodes decides to allocate the fifth time slot within each frame on bitstream 202 and that the second intermediate node decides to allocate the seventh time slot within each frame on bitstream 203. Thus, a slot mapping problem is present, since the allocated additional time slots occupy the last position within the channel on bitstreams 201 and 203, but the second last position on bitstream 202 and the first position on bitstream 203. If mapping were to be established from the third time slot on bitstream 201 to the fifth time slot on bitstream 202 and then to the seventh time slot on bitstream 203, the sequential order of any data provided in time slots at the sending node would not be preserved.

Thus remapping is needed. In this embodiment the remapping is performed starting from the last intermediate node. Hence, the second intermediate node will stop mapping data from the fourth time slot on bitstream 202 to the eighth time slot on bitstream 203 and instead start mapping data from the fourth time slot on bitstream 202 to the seventh, newly allocated time slot on bitstream 203. At the same time, the second intermediate

node will start mapping data from the newly allocated fifth time slot on bitstream 202 to the eighth time slot on bitstream 203. Note, however, that if any one of the intermediate nodes allocate an additional time slot to the channel before a mapping thereto is defined, the node must make sure that, during the mean time, information designating said additional time slot as not providing payload data is provided accordingly.

Then, having received a control message from the last, i.e. the second, intermediate node informing that the mapping at the second intermediate node is complete, the second last, i.e. the first, intermediate node may at any time make its mapping decision and will then select to stop mapping data from the second time slot on bit-stream 201 to the sixth time slot on bitstream 202 and instead start mapping data from the second time slot on bitstream 201 to the fifth, newly allocated time slot on bitstream 202. At the same time, the first intermediate node will start mapping data from the newly allocated third time slot on bitstream 201 to the sixth time slot on bitstream 202.

When the first intermediate node then informs the sending node that allocatiion of resources and the neces-sary mapping has been accomplished, the sending node may at any time start using the additional time slots for transmitting payload data, as dicussed above.

The manner in which the features and functions according to the invention may be realized, implemented, and put into practice is straightforward, as is readily understood by those skilled in the art of network software programming, and further description thereof is therefore omitted. Also, the scope of the invention is not to be limited by the exemplifying embodiments thereof disclosed herein, while combinations and modifications thereof, as will be evident for those skilled in the art, may be perforemed within the scope of the invention, which is defined by the accompanying claims.

CLAIMS

1. A method for increasing the bandwidth of an existing isochronous channel in a circuit switched time division multiplexed network of the kind wherein data are transferred on bitstreams, each bitstream being divided into recurrent frames and each frame being divided into time slots, said isochronous channel comprising a set of time slots within each frame of a bitstream between a first node and a second node, said method comprising the steps of:

allocating to said channel, in addition to said set of time slots, one or more additional time slots within each frame of said bitstream;

using, during a period of time, only a subset of the time slots of the enlarged set of time slots formed by said a set of time slots and said one or more additional time slots for transmitting payload data pertaining to said channel, the number of time slots in said subset of time slots not exceeding the number of time slots in said a set of time slots, and providing, during said period of time, said bitstream with information indicating that the remaining time slots of said enlarged set of time slots are currently not used for transferring payload data; and

using, after said period of time, said a set of time slots as well as said one or more additional time slots on said bitstream for transmitting payload data pertaining to said channel.

2. A method as claimed in claim 1, wherein said step of using, during a period of time, only a subset of the time slots comprises:

using, during said period of time, only said a set of time slots for transmitting payload data pertaining to said channel and providing, during said period of time, said bitstream with information indicating that said one

or more additional time slots are currently not used for transferring payload data.

3. A method as claimed in claim 1 or 2, wherein the end of said period of time is related to the reception of information indicating that one or more nodes handling said channel are ready to receive payload data pertaining to said channel from said one or more additional time slots.

4. A method as claimed in claim 1, 2 or 3, wherein said first node manages the allocation of said one or more additional time slots to said channel on said bitstream and provides said second node with information requesting that said one or more additional time slots are to be part of said channel.

5. A method as claimed in claim 4, wherein said second node, having received said information requesting that said one or more additional time slots are to be part of said channel and having made any necessary arrangements for being able to handle payload data received in said one or more time slots, provides said first node with confirmation information indicating that said second node is ready to start receiving payload data from said one or more additional time slots.

6. A method as claimed in claim 5, wherein said period of time ends after the reception of said confirmation information at said first node.

7. A method as claimed in any one of the preceding claims, wherein said channel further comprises another set of time slots on another bitstream between said second node and a third node, and wherein said method comprises the further steps of:

allocating to said channel, in addition to said another set of time slots, one or more additional time slots within each frame of said another bitstream; and

providing mapping between the time slots forming said channel on said a bitstream and the time slots forming said channel on said another bitstream, as well as, or thereby providing, mapping of said information designating the time slots that are currently not used for transferring payload data.

8. A method as claimed in claim 7, wherein said further steps are performed at said second node.

9. A method as claimed in claim 8, wherein said second node, having allocated said one or more additional time slots, having established said mapping, and having made any other necessary arrangements for being able to handle payload data received in said one or more time slots, provides said first node with said confirmation information indicating that said second node is ready to start transferring payload data from said one or more additional time slots allocated to said channel on said a bitstream.

10. A method as claimed in claim 9, wherein said feature of having made said arrangements for being able to handle payload data comprises notifying and receiving acknowledgement from said third node that said one or more additional time slots allocated to said channel on said another bitstream are now to be part of said channel.

11. A method as claimed in claim 9 or 10, wherein said period of time ends after the reception of said confirmation information at said first node.

12. A method as claimed in any one of the preceding claims, wherein re-mapping to be performed with respect to the time slots forming the channel at said second node, as a result of the change of the amount of resources allocated to said channel, is carried out after the completion of any re-mapping performed among the time slots forming the channel at a node handling said channel and being arranged downstream with respect to said second node.

13. A method for increasing the bandwidth of an existing isochronous communication channel in a circuit switched time division multiplexed network of the kind wherein data are transferred on bitstreams, each bitstream being divided into recurrent frames and each frame being divided into time slots, said channel comprising a first set of time slots within each frame of a first bitstream and a second set of time slots within each frame of a second bitstream, said method being performed at an intermediate node which provides mapping between said first set of time slots and said second set of time slots, said method comprising the steps of:

receiving information requesting allocation of additional resources to said channel;

allocating to said channel, in addition to said second set of time slots, one or more additional time slots within each frame of said second bitstream; and

providing, if an instruction to start mapping data from one or more additional time slots on said first bitstream has not yet been received, only said second set of time slots with payload data and said second bitstream with information designating the time slots of the time slots allocated to said channel on said second bitstream that are currently not used for transferring payload data.

14. A method as claimed in claim 12, comprising:

receiving information indicating which one or more additional time slots within each frame of said first bitstream that have been allocated to form said additional resources on said first bitstream;

providing mapping between the time slots forming said channel on said first bitstream and the time slots forming said channel on said second bitstream; and

transmitting information indicating that said intermediate node is ready to start transferring payload data from said one or more additional time slots time slots on said first bitstream.

15. A method as claimed in claim 12, wherein said step of transmitting information is performed after having received acknowledgement from one or more downstream nodes handling said channel that they are ready to receive payload data from said one or more additional time slots.

16. A method as claimed in claim 12, 13, or 14, wherein any re-mapping to be performed with respect to the time slots forming said channel at said intermediate node, as a result of the change of the amount of resources allocated to said channel, is carried out after the completion of any re-mapping performed among the time slots forming the channel at a node handling said channel and being arranged downstream with respect to said intermediate node.

17. A method for decreasing the bandwidth of an existing isochronous channel in a circuit switched time division multiplexed network of the kind wherein data are transferred on bitstreams, each bitstream being divided into recurrent frames and each frame being divided into time slots, said isochronous channel comprising a set of time slots within each frame of a bitstream between a

first node and a second node, said method comprising the steps of:

said first node using, during a period of time, only a portion of said set of time slots for transmitting payload data pertaining to said channel and providing said bitstream with information indicating that the remaining time slots of said set of time slots are currently not used for transferring payload data;

said first node providing said second node with information declaring that said remaining time slots are to be deallocated from said channel; and

said first node, after said period of time, deallocating said remaining time slots of said first set of time slots from said channel while discontinuing providing said information indicating that said remaining time slots of said set of time slots are currently not used for transferring payload data.

18. A method as claimed in claim 16, wherein said second node provides said first node with confirmation information acknowledging that said remaining time slots are no longer to be part of said channel and wherein the end of said period of time occurs after the reception of said confirmation information at said first node.

19. A method as claimed in claim 16 or 17, wherein any re-mapping to be performed with respect to the time slots forming said channel at said second node, as a result of the change of the amount of resources allocated to said channel, is carried out after the completion of any re-mapping performed among the time slots forming the channel at a node handling said channel and being arranged downstream with respect to said second node.

20. A method for increasing the bandwidth of an existing isochronous channel in a circuit switched time division multiplexed network of the kind wherein data are

transferred on bitstreams, each bitstream being divided into recurrent frames and each frame being divided into time slots, said isochronous channel comprising a set of time slots within each frame of a bitstream between a first node and a second node, said method comprising the steps of:

said first node allocating to said channel, in addition to said set of time slots, one or more additional time slots within each frame of said bitstream;

said first node providing said second node with information requesting that said one or more additional time slot are to be part of said channel;

said first node, while waiting for information confirming that said one or more additional time slots may be used for providing payload data, using only said set of time slots for transmitting payload data pertaining to said channel and providing said one or more additional time slots with time slot data indicating that they are currently not used for transferring payload data;

said second node, having received said information requesting that said one or more additional time slot are to be part of said channel and having made any necessary arrangements for being able to handle payload data received in said one or more time slots, providing said first node with confirmation information indicating that said second node is ready to start receiving payload data from said one or more additional time slots; and

said first node, having received said confirmation information, using said first set of time slots as well as said one or more additional time slots on said bitstream for transmitting payload data pertaining to said channel.

21. A method for changing the bandwidth of an existing isochronous communication channel in a circuit switched time division multiplexed network of the kind

wherein data are transferred on bitstreams, each bitstream being divided into recurrent frames and each frame being divided into time slots, wherein an intermediate node provides mapping of time slots allocated to said channel on a first bitstream and time slots allocated to said channel on a second bitstream, said method comprising the step of:

performing, at said intermediate node, any re-mapping with respect to the time slots forming said channel at said intermediate node, required as a result of the change of the amount or resources allocated to said channel, after the completion of any required re-mapping performed among the time slots forming said channel at a node handling said channel and being arranged downstream with respect to said intermediate node.

22. A method as claimed in any one of the preceding claims, wherein said information indicating that a time slot is not used for transferring payload data is provided by the step of marking said time slot as idle.

23. A method as claimed in claim 21, wherein said step of marking said time slot as idle comprises writing idle time slot identifying data, such as an identifiable code word, into said time slot.

24. A method as claimed in claim 11, 12, 18, or 20, wherein said re-mapping comprises switching from an old mapping instruction to a new mapping instruction at frame start.

25. A method as claimed in any one of the preceding claims, wherein said network is a Dynamic synchronous Transfer Mode (DTM) network.

ABSTRACT

The present invention relates to methods for changing the bandwidth of an existing isochronous channel in a circuit switched time division multiplexed network of the kind wherein data are transferred on bitstreams, each bitstream being divided into recurrent frames and each frame being divided into time slots, said isochronous channel comprising a set of time slots within each frame of a bitstream between a first node and a second node.

According to the invention, having allocated to said channel, in addition to said set of time slots, one or more additional time slots within each frame of said bitstream, only a subset of the time slots of the enlarged set of time slots formed by said a set of time slots and said one or more additional time slots is used, during a period of time, for transmitting payload data pertaining to said channel, the number of time slots in said subset of time slots not exceeding the number of time slots in said a set of time slots, while, during said period of time, said bitstream is provided with information indicating that the remaining time slots of said enlarged set of time slots are currently not used for transferring payload data. Then, after said period of time, said a set of time slots as well as said one or more additional time slots on said bitstream are used for transmitting payload data pertaining to said channel.

Elected for publication: Fig. 3c

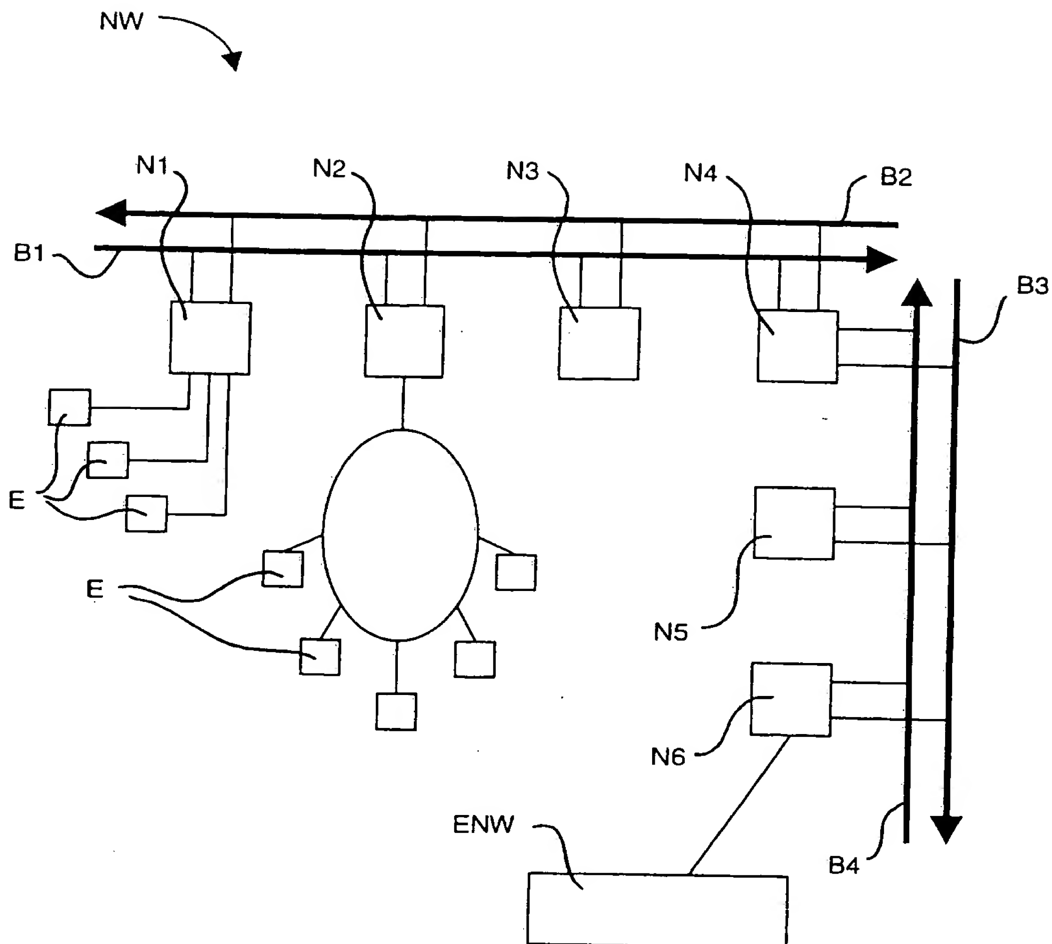


FIG. 1

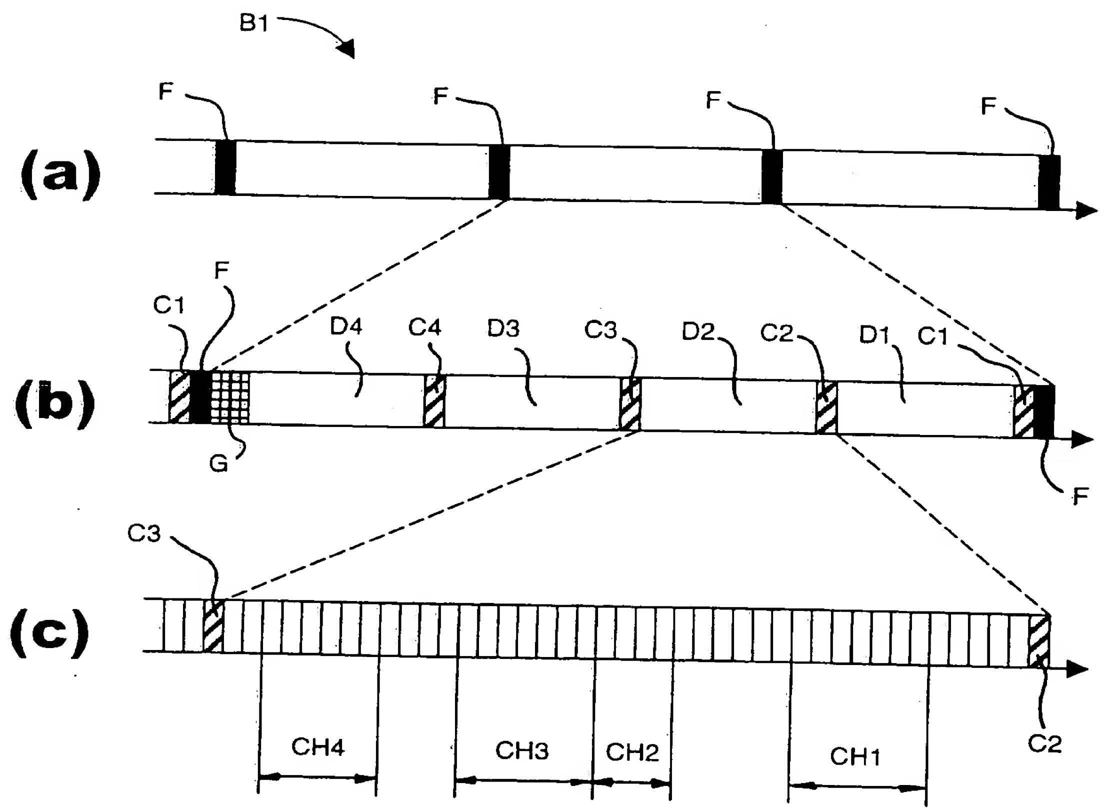
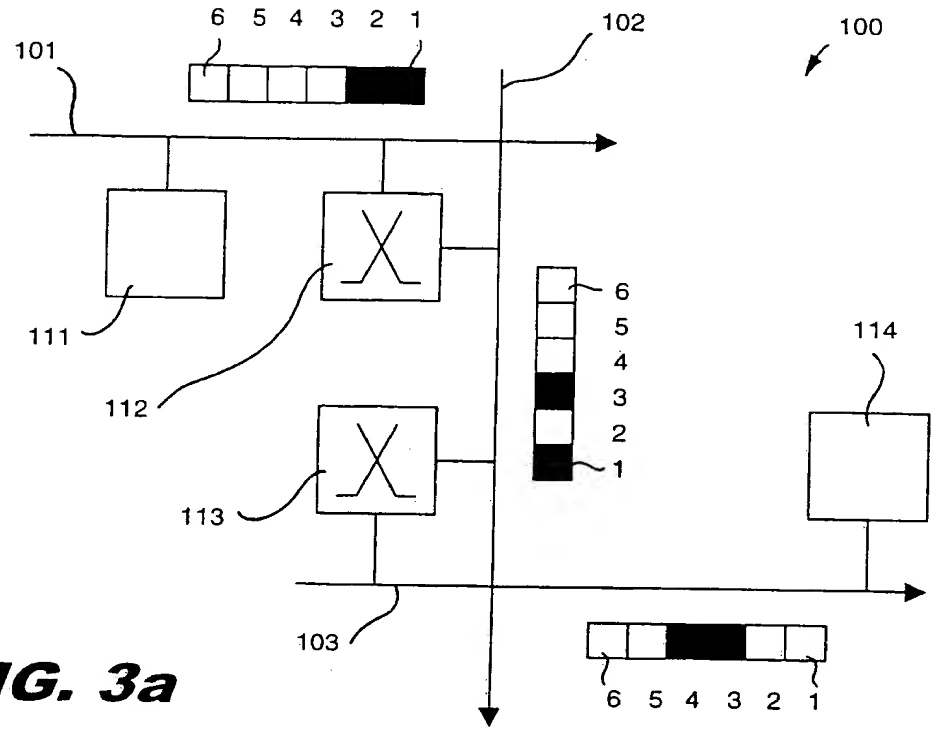


FIG. 2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112
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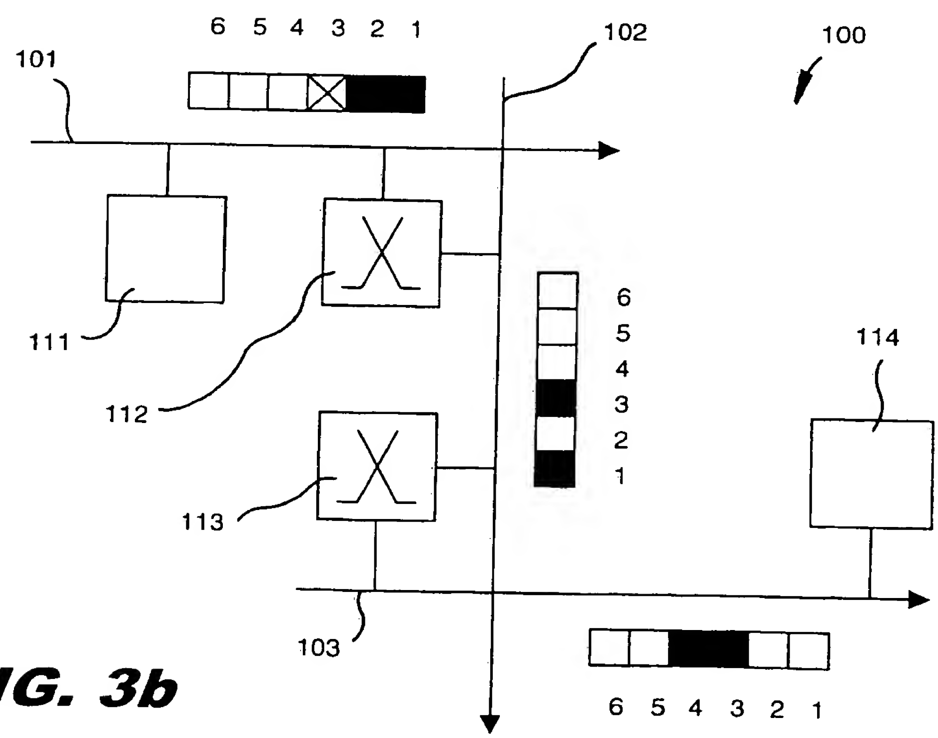
5
4
3
2
1
114
113
103
6 5 4 3 2 1

FIG. 3a


6 5 4 3 2 1
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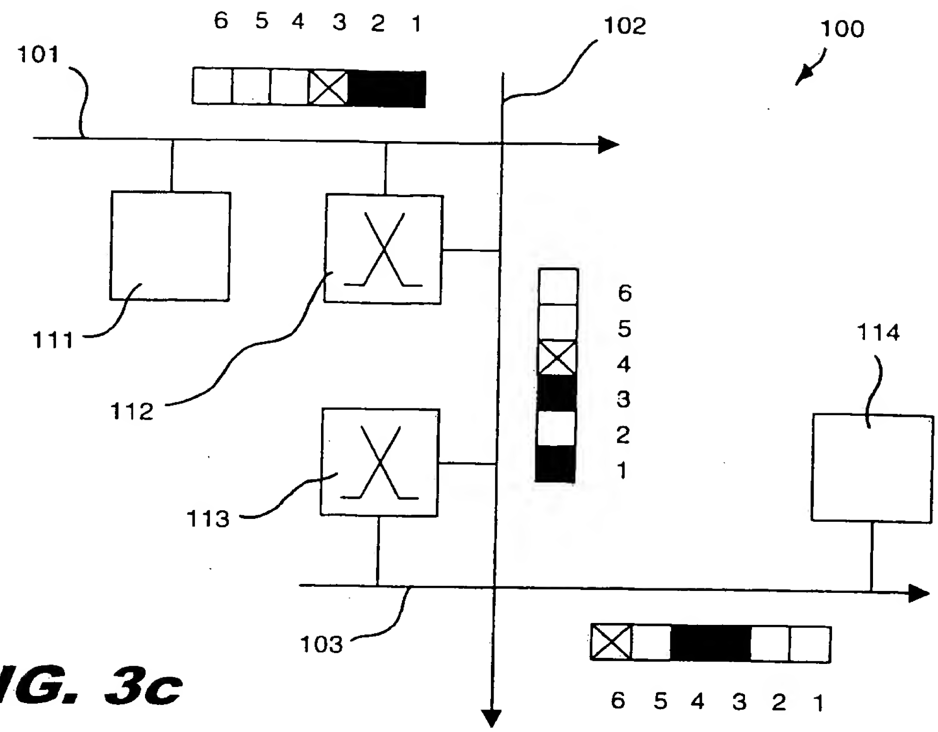
102
100
111
112
6
5
4
3
2
1
114
113
103
6 5 4 3 2 1

FIG. 3b



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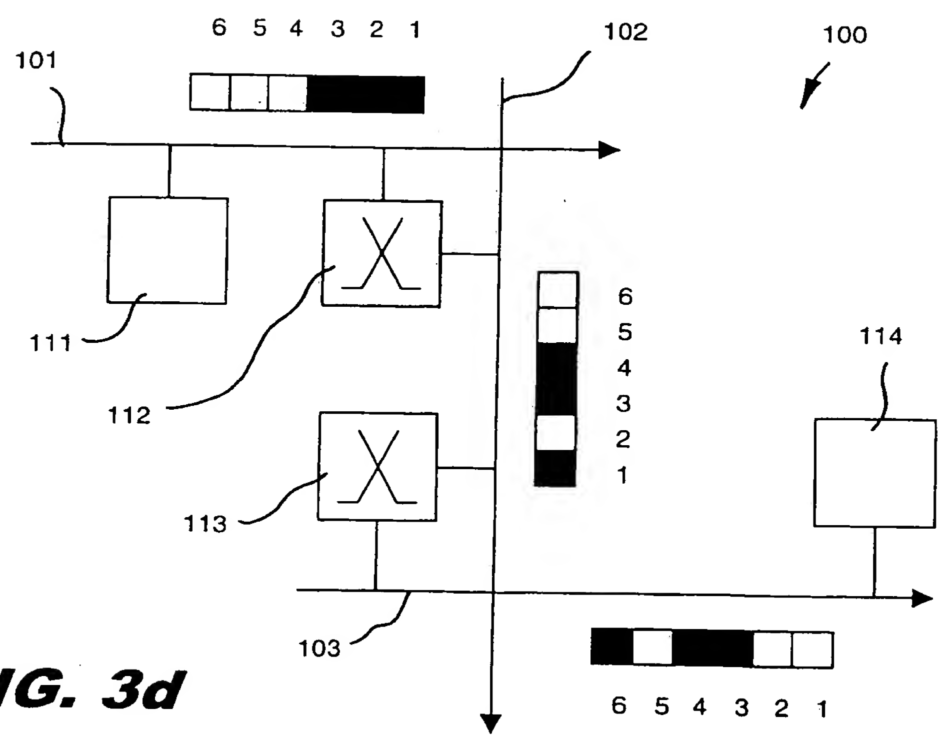
101
102
100
111
112
113
114
103
6 5 4 3 2 1
6 5 4 3 2 1

FIG. 3c



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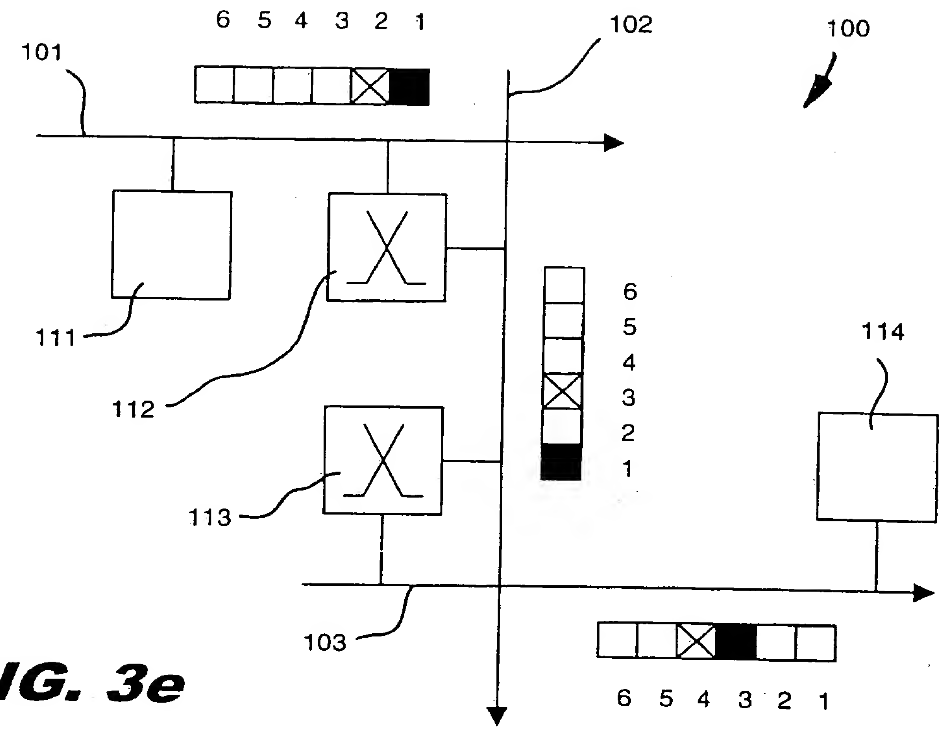
100
111
112
113
114
103
6 5 4 3 2 1
6 5 4 3 2 1

FIG. 3d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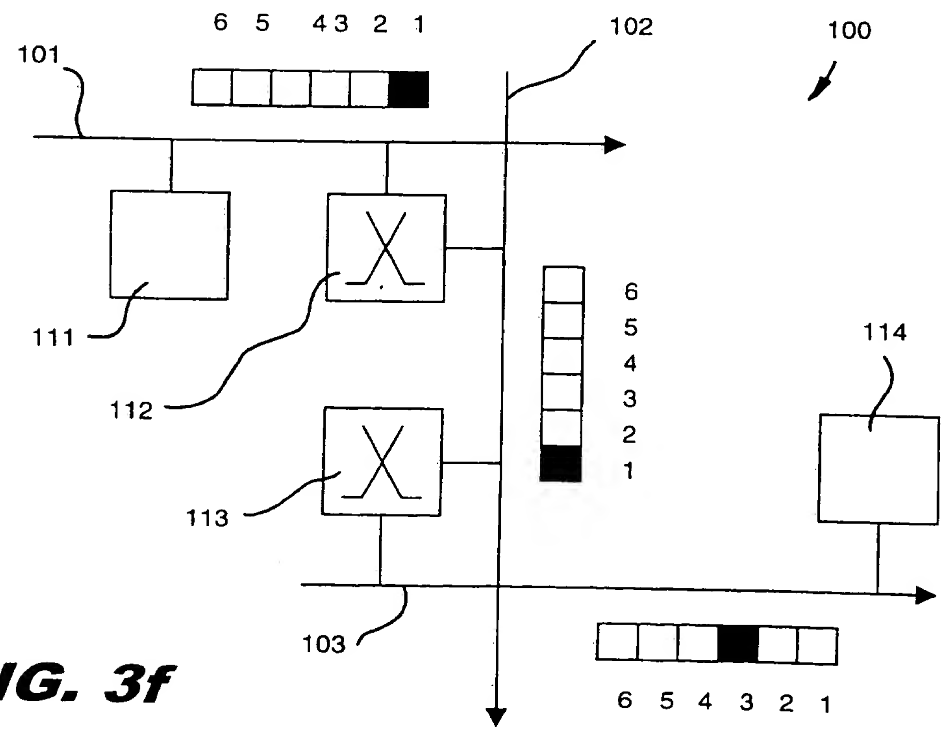
6 5 4 3 2 1

FIG. 3e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114
6
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4
3
2
1
103
6 5 4 3 2 1

FIG. 3f

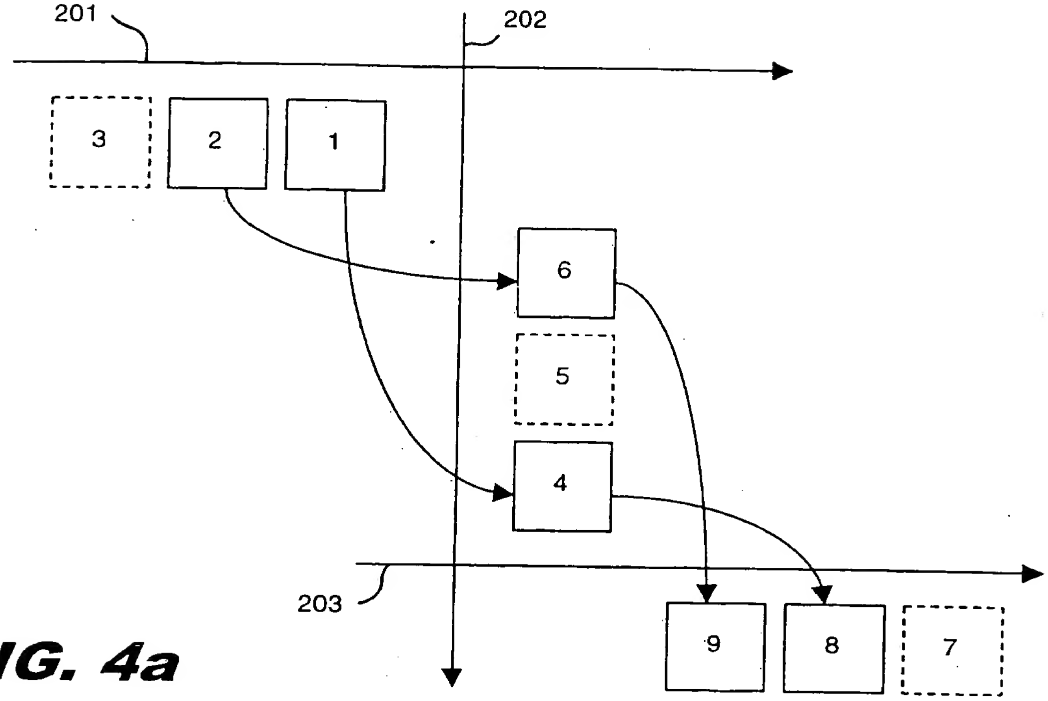

FIG. 4a

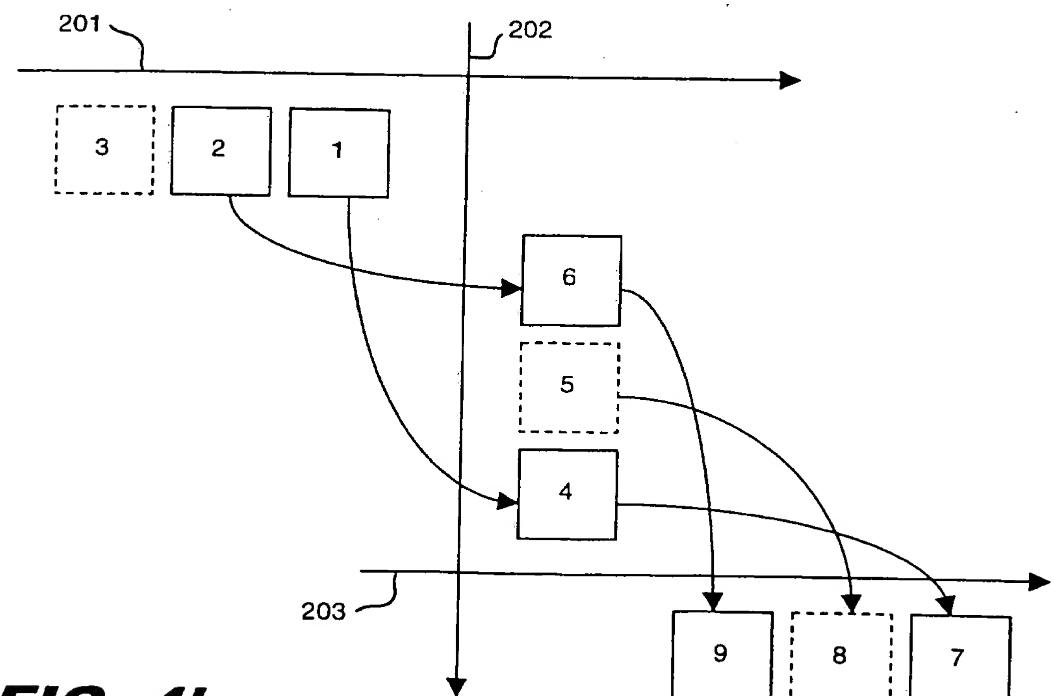

FIG. 4b

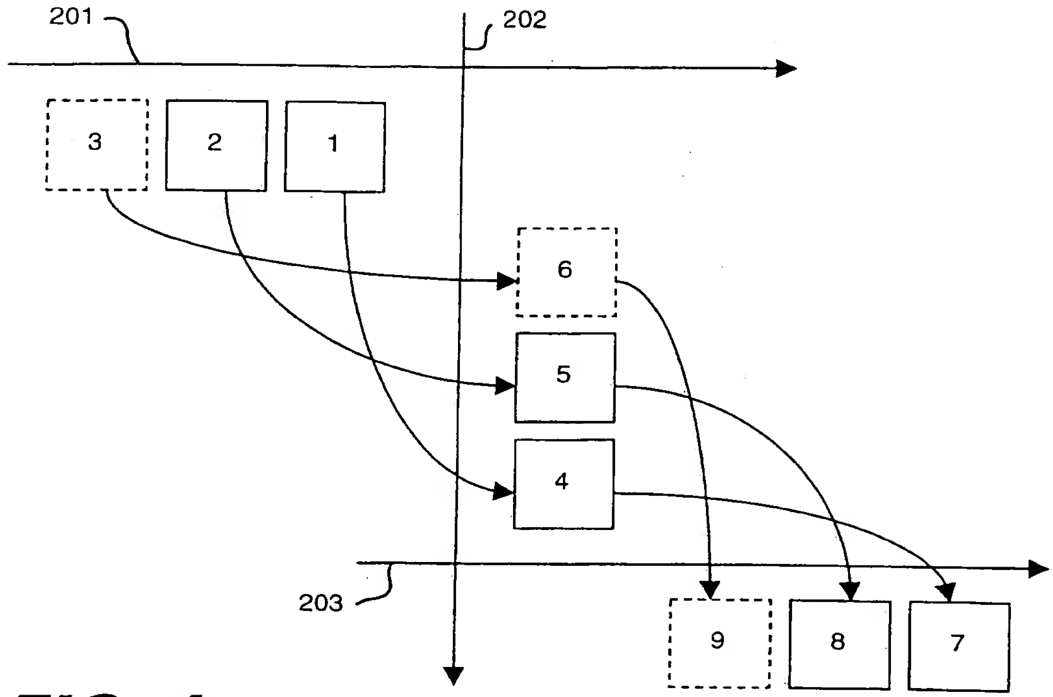

FIG. 4c